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Prespective

Ecosystem services and legal protection of private property. Problem or solution?

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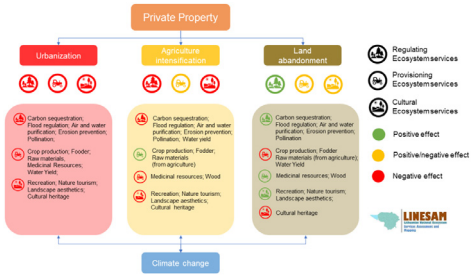
HIGHLIGHTS

- Private property imposes challenges to the delivery of ES in quality and quantity;
- Land-use changes affect the capacity of the ecosystems substantially to provide ES;
- Communication should be simple to private owners to increase the awareness about ES;
- PES should respect the local realities, traditions and contribute to poverty alleviation;
- Private owners' cooperation is the key to achieve global goals (e.g., SDGs);

GRAPHICAL ABSTRACT



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ABSTRACT

Ecosystem services (ES) delivery in quantity and quality are essential to improve human wellbeing. Nevertheless, often a considerable part of ES provisioning depends on the use of private land (e.g., flood retention, carbon sequestration, water purification). In this context, the operationalization and implementation of ES concept may collide with legal property rights. Therefore, it is essential to find constructive mechanisms to engage and encourage private owners to implement sustainable land uses to reduce the onsite and offsite impacts of their activities. This paper aims to identify if ES delivery can be constrained by legal private land and how it can be tackled. It is undeniable that land-use changes (e.g., urbanization, agriculture intensification, and land abandonment) affect the territory's capacity to deliver ES in quality and quantity. These changes, especially land abandonment, are increasing the tradeoffs among ES (e.g., between carbon sequestration and water yield). Land-use planning should consider these aspects. Therefore, incorporating ES into spatial plans is crucial for stakeholders to understand the impacts of land-use change in the loss of ES value. This information can be transmitted through maps that communicate the message in a simplified way. Private owners can easily perceive the ES relevance that their land can provide if an understandable message is delivered. Although this can be a good solution, conflicts can appear even with the implementation of schemes such as Payment for ES (PES). PES is not always effective and can impose losses to farmers, disregard their cultural traditions, or not prevent poverty alleviation. In this context, it is crucial to consider local specificities to safeguard PES's success, create a "win-win" and transform a problem into a solution. Private owners' active participation in implementing sustainable practices or a determined land-use in their properties is vital to achieving global targets such as sustainable development goals.

1. Background

Ecosystem services (ES) are defined as the benefits that humans get from nature (Millennium Ecosystem Assessment, 2005). There are several classifications, however, they are usually divided into regulating

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ES, provisioning ES, and cultural ES. It is widely known that ES has a relevant socio-economic component and contributes with several benefits for human wellbeing (Leviston et al., 2018; Yang et al., 2019). Therefore, the incorporation of ES in territorial planning is crucial step to operationalize this concept and has gained a presence in policy-making in several international organizations such as European Union (Bouwma et al., 2018) or United Nations (UN) (Shamshad, 2012). This is a critical factor in the implementation of the UN Sustainable Development Goals (SDGs) (Wood et al., 2018). Despite the global importance, ES concept has been criticized by several for the anthropocentric focus (e.g., Redford and Adams, 2009), monetarization of nature, and to be an ineffective way to protect biodiversity (Temel et al., 2018). Both ES and natural capital concepts "*define nature in anthropocentric terms*." To some extent, there is the idea that ES concept is being "oversold". Overall, nature will only be preserved if it offers a value (Silvertown, 2015), and this does not seem ethically correct or valuable for biodiversity conservation. Also, the multitude of classifications increases the ambiguity of ES concept (e.g., Ojea et al., 2012).

On the other hand, a long list of works claimed that ES concept could support several human and ecological aspects such as biodiversity conservation (e.g., Schroter et al., 2014), poverty alleviation (Daw et al., 2011), sustainable resources management (Grêt-Regamey et al., 2017), risk assessment (Faber et al., 2019), aquaculture systems (Witzman, 2019), social ecology (Schleyer et al., 2017), climate protection (Schetke et al., 2018) and land-use planning (Di Marino et al., 2019). Also, it can be integrated in well-known methodologies such as environmental impact assessment (Rosa and Sanchez, 2016), strategic environmental assessment (Rozas-Vasquez et al., 2019), life cycle assessment (Liu et al., 2020). Although ES concept has a wide application, it is widely known that there is an important number of tradeoffs between ES, especially between regulating/cultural and provisioning (e.g., Depellegrin et al., 2016; Lee and Lautenbach, 2016; Sil et al., 2016). This may impose conflicts between the different stakeholders (e.g., Wam et al., 2016; Kim and Arnhold, 2018) and make the operationalization and implementation of ES concept difficult in practice. These barriers have been highlighted in previous works (e.g., Grêt-Regamey et al., 2017; Jax et al., 2018). One of the most significant barriers to implementing the ES concept is the restrictions related to legal protection of private property, since the planning often depends on the will of the owners to accept the ideas and consider them in their lands. Often to encourage the landowner to manage their land in a particular way, compensations schemes are needed (Rickenbach et al., 2011; Vedel et al., 2015), such as Payment for ES (PES) (e.g., Farley and Constanza, 2010; Matthies et al., 2015; Banerjee et al., 2017). In this context, it is key to understand the conflicts and the difficulties of ES concept implementation in legal private land and how to tackle them. This paper aims to assess the importance of ES concept in legal protection of private property and evaluate the problems and solutions in their operationalization in private property. A case study focused on the impacts of land use on ES supply and demand to mediate waste or toxin substances of anthropogenic origin in Lithuanian are included in the manuscript, to exemplify how ES mapping can support territorial planning.

2. Ecosystem services and land-use planning

2.1. Short background

Land-use change is one of the most important drivers of change, responsible for ES degradation (Pereira, 2020). A large number of works highlighted the impacts of urbanization (e.g., Li et al., 2016) agriculture intensification (e.g., Pereira et al., 2018) and land abandonment (e.g., Quintas-Soriano et al., 2016) in the reduction of ES supply. This has tremendous importance since most of the land-use changes occur in private property.

Urbanization is a form of land consumption that destroys all the ES provided by the soil. When soil is sealed, key soil ES such as carbon storage, water infiltration, or climate regulation, are lost. Fertile agriculture soils are destroyed, reducing drastically their capacity to provide food (Pereira et al., 2020). This is still a reality in several areas of the world, such as in Egypt (Shalaby and Moghanm, 2015), Turkey (Doygun, 2009), Nepal (Rimal et al., 2018), and Spain (Perez and Garcia, 2016). Also, urban soils are an important sink of heavy metals and other emergent pollutants, becoming a disservice to humans since they are exposed to high contamination levels with potential impacts on human health (Brevik et al., 2020). Vegetation removal reduces the biodiversity, but also air purification, microclimate regulation, noise regulation, carbon and water storage, oxygen generation, flood regulation, pollutants retention, and recreation (e.g., Jim and Chen, 2009; Daryanto et al., 2019; Carvalho and Szlafsztein, 2019). This normally results in a reduction of environmental quality.

As a consequence of population increase, the increase of food demand and market pressure for cash crops, augmented agriculture intensification, and land transformation for farming (i.e. croplands and livestock) (Vongvisouk et al., 2016; Duro et al., 2020). Agricultural land conversion is one of the most important drivers of biodiversity loss (Lanz et al., 2018). Agriculture intensification is a consequence of the use of heavy machinery, fertilizers, and herbicides to increase and protect crop yields. These practices increase soil degradation and the dilapidation of soil functions and ES onsite and offsite (Pereira et al., 2018a). The percolation of pollutants in agriculture areas is responsible for contaminating groundwater resources (e.g., Sorando et al., 2019). Also, the transport of pollutants in overland flow and sediment decrease the water quality (e.g., eutrophication, microplastics, emerging pollutants, salinization, microbiological contamination) and biodiversity (Pardo and Garcia, 2016; Xue et al., 2018; Evans et al., 2019; Pereira, 2020).

Land abandonment is a social phenomenon with significant implications on the environment. The abandonment of rural areas increased the rewilding of farming areas, and some authors observed that this has a positive effect on some ES (e.g., carbon storage) (Novara et al., 2017) and negative on others (e.g., water yield) (Ovando et al., 2019). The rewilding of abandoned croplands is a question of debate regarding the impacts on the environment. Some are positive (e.g., increase habitat for species traditionally hunted) and the others, negative (e.g., decrease of species dependent on agro-pastoral activities) (Garcia-Baron et al., 2017). Also, in terraced landscapes, due to the lack of maintenance, terraces may collapse and increase soil erosion and landslides (Moreno-de-las-Heras et al., 2019). Land abandonment impacts cultural values due to the loss of millennial landscapes and cultural heritage. This represents a significant loss of cultural ES, mainly because, in many cases, these areas are occupied by monocultures (Hanaček and Rodríguez-Labajos, 2018). Overall, there are important ES tradeoffs due to land abandonment (van der Zanten et al., 2017).

The human activities are responsible for the rapid and unprecedented climate change. Global warming is strongly affected by the accelerated urbanization (e.g., urban heat island) (Vahmani et al., 2016) and agriculture intensification (e.g., greenhouse gases emission) (Jain et al., 2016). These human activities have a strong impact on climate change, responsible for the increase in the length of drought periods, irregular and intense rainfall events, or sea-level rise. The change in weather patterns and extreme events impose high pressure on the ecosystems affecting their capacity to provide ES. The effects of climate on ES are spatially different, and in some areas can have a positive effect (e.g., forest productivity), while in others a negative one (e.g., water supply, wildfires). Overall, climate change imposes a cumulative effect to the impacts of urbanization, agriculture intensification, and land abandonment. The impacts of climate change on ES are considered lower than human activities (Pereira, 2020).

ES are substantially affected by human activities (Pereira, 2020). In this context, land use planning has a vital role in the mitigation of these impacts. The incorporation of ES concept in spatial plans is crucial to evaluate the impacts of land-use change on the services pro-

vided by an ecosystem. ES importance in land use planning has been highlighted in a substantial number of works in several parts of the world such as in China (Liang et al., 2017), Bangladesh (Mukul et al., 2017) The USA (BenDor et al., 2017), Canada (Tam and Conway, 2018), Sweden (Kaczorowska et al., 2016), Finland (Di Marino et al., 2019), Hungary (Pinke et al., 2018), Spain (Martinez-Sastre et al., 2017), Italy (Salata et al., 2020), The Netherlands (Fürst et al., 2014), France (Brunet et al., 2018), Indonesia (Sumarga and Hein, 2014) and Australia (Sandhu et al., 2018) therefore, is a topic with global relevance. Incorporating ES in spatial planning is a crucial step since we can have an idea about the ecosystem values, despite the uncertainties related to economic evaluation. It is also important to understand the ES losses and gains related to a potential change of land use. Fürst et al. (2014) summarized the advantages of including ES in land use planning as 1) social network and collaboration, 2) share knowledge, and 3) shared vision. There are also several critical aspects essential to the success, such as identifying the supply and demand relations, integrating socio-economical aspects on planning exercise, and the participants' knowledge level. Despite the advantages of integrating ES in land use planning, the term "ES" rarely appears in official documents (e.g., Piwowarczyk et al., 2013; Tam and Conway, 2018), limiting the discussion about the land-use change impact on ES.

Maps are an important communication tool and simplify environmental processes (Pereira et al., 2018b). ES maps can transfer easily ES relevance and information, therefore are an important communication vehicle with stakeholders and decision-makers. In this context, there are an important number of studies focused on mapping ES at different scales, including national (Depellegrin et al., 2016), regional (Schmalz et al., 2016), local (Maes et al., 2019) that can be used by different levels of administration to improve land use planning. A better knowledge about the ES capacity, supply, flow, and demand will contribute to better decisions and ensure critical aspects of human well-being, such as food security, climate change mitigation, clean water, biodiversity, flood risk mitigation, human health, recreation, and cultural values protection.

2.2. *Case study: Mapping supply and demand mediation of wastes or toxins substances of anthropogenic origin by living processes in Lithuania*

To illustrate an example of how land use can affect ES, we mapped the mediation of wastes or toxins substances of anthropogenic origin by living processes (filtration/sequestration/storage/accumulation by microorganisms, algae, plants and animal) supply and demand in Lithuania. ES supply refers to an area's capacity to provide a number of ES within a given period, whereas ES demand corresponds to the sum of all ES used in a specific area within a period (Burkhard et al., 2012). We identified the areas that can reduce the impact of diffuse pollution from agricultural and urban settlements in water bodies. The areas where the agriculture area (southwest) is large and near the major cities (Vilnius and Kaunas) is where the supply is low (Fig. 1a). The Moran's *I* autocorrelation analysis showed that the supply has a clustered pattern (z-score: 21.86, $p<0.001$). This is confirmed by the hot-spot analysis that identified areas with significantly lower supply to mediate wastes or toxins substances (agricultural areas in the southwest and major cities) (Fig. 1b). For more information about spatial autocorrelation (Moran's *I*) and hot-spot analysis, please consult Comin et al. (2018) and Inácio et al. (2020). Concerning the demand for mediation of waste or toxins, substances was high near the major urban areas and in the agriculture (located at the southwest and north) (Fig. 1c). As in the supply, the spatial pattern is significantly clustered (z-score: 22.89, $p<0.001$). The areas with a significantly high capacity to mediate waste or toxins are located in the east and south (Forest areas) and significantly low in agricultural and urban areas mentioned previously (Fig. 1d). Fig. 2 showed the relation between GiZ Score of Supply and GiZ Score of Demand obtained from the mediation of wastes or toxin substances hot spot analysis. It is observed a negative relation ($r^2=0.25$) that is not so high, but statistically significant. This confirms that the elderships with a high need to mediate wastes or toxins substances are less capable of doing it. From a land-use planning perspective, it is clear in Lithuania that, near the urban areas and in the southwestern part of the country, more efforts are needed to increase the ecosystems' capacity to mediate waste or toxins, since they have reduced supply and high demand. These areas have a high priority for restoration. An important measure that could be applied in these to increase the ecosystem capacity to reduce the number of pollutants from urban or agriculture origin is, if possible, the restoration of riparian forests to retain sediments and contaminants. Fig. 3 shows a watercourse in Lithuania's intensive managed agricultural area, where no vegetation strip was established. Watercourses managed as this one has a reduced capacity to mediate waste or toxins, offering poor protection against the impact of intensive agriculture practices in surface hydrological resources. It is fundamental to raise awareness in private owners to establish a riparian forest network to limit the amount of sediments and contaminants that reach the water bodies.

3. Legal restrictions related to private property

The protection of private land is one of the most important rights belonging to a natural or legal person. Very often, it has the highest possible protection within the national legal system – it is protected by the state's constitution, for instance, Article 23 of the Lithuanian Constitution (Supreme Council of the Republic of Lithuania, 1992), Article 64 of Polish Constitution (SEJM, 1997). On the international level Article 1 of the Protocol No. 1 to the European Convention on Human Rights provides that "Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law" (Council of Europe, 1952). Notable that other international and regional conventions also provide for a strong protection of the property, for instance, the American Convention on Human Rights (OAS, 1969).

The strength of the constitutional protection varies from state to state and may be very strong (e.g., in USA), medium (e.g., in Canada), and minimal (e.g., in Germany) (Tarlock and Albrecht, 2018). The protection usually includes restriction of expropriation, possibility to use the property according to the owner's wishes, buy or sell the asset (Alston and Mueller, 2008). However, the right to property is not unlimited, it can be subject to particular restrictions posed by the state due to the important public interests (Tarlock and Albrecht, 2018). Rules of the interference to the legal protection of private property by a state may be derived from the rich case-law of the European Court of Human Rights (ECHR). It is important to note that this jurisprudence is binding the states, parties to the Protocol No.1 of the ECHR. Therefore, their national rules and case-law should not run counter the jurisprudence of the ECHR.

The ECHR establishes the basic principles of property protection. The state can control the use of the legal protection of private property in accordance with the general interest (ECHR, 2020). However, interference in private property's legal protection should be the criteria of lawfulness, proportionality, and serve public or general interest (ECHR, 2020). The first principle means that interference has to be allowed by the legal act, which protects from arbitrariness and is compatible with the rule of law (ECHR, 2020). The existence of a public or a general interest means that there is a public concern, legitimate public purpose (ECHR, 2020). According to the ECHR the protection of the environment is considered as public interest (ECHR, 2018). Finally, proportionality means that between the enjoyment of the legal protection of private property and the public interest must be a "fair balance" (ECHR, 2020), which means that restriction imposed on the owner of the property must be proportional to the aim that the state is seeking to achieve. In the case of the environment, the ECHR has stated that the environment's protection is a

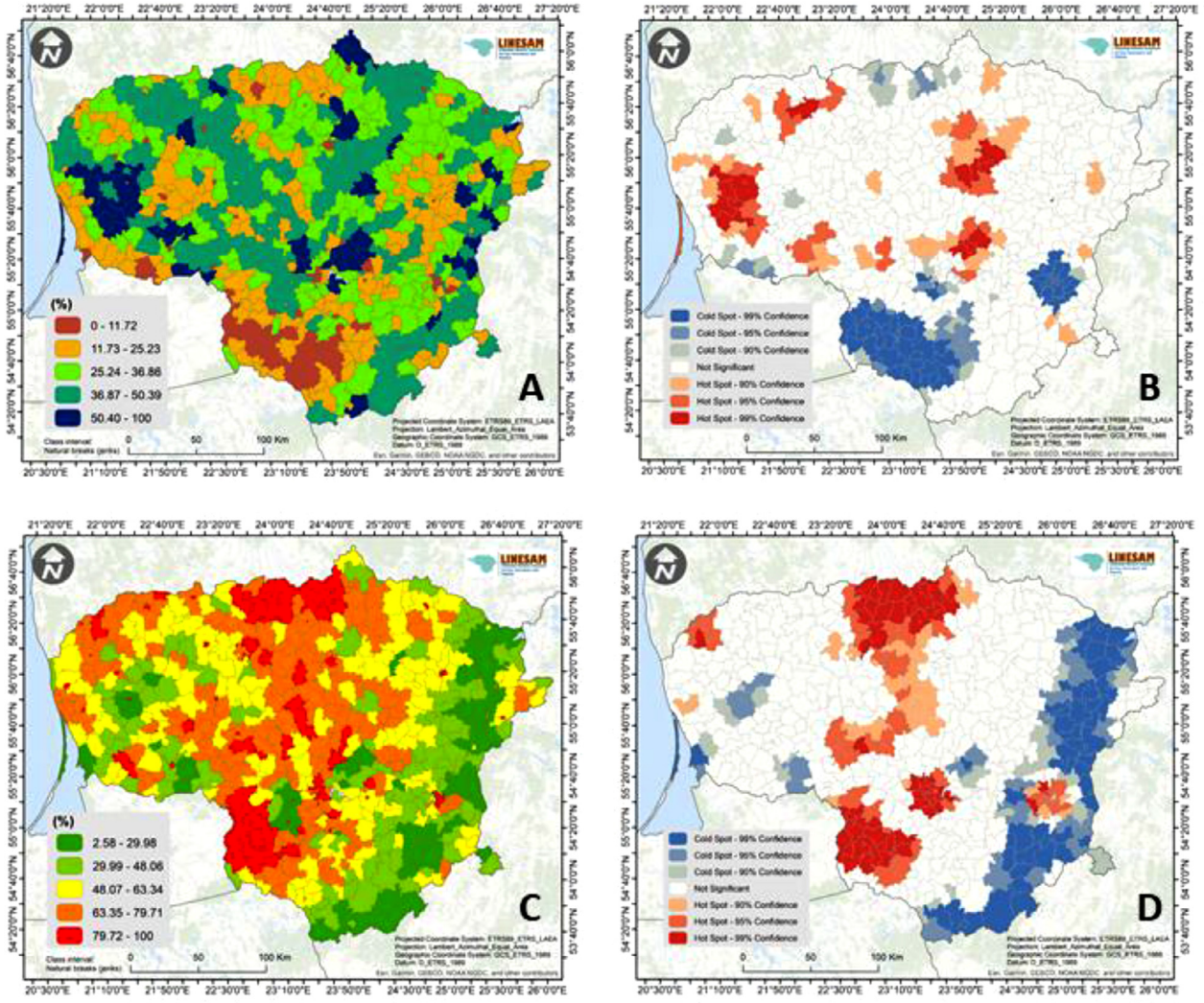

Fig. 1. Mediation of wastes or toxins substances of anthropogenic origin by living processes (filtration/sequestration/storage/accumulation by microorganisms, algae, plants and animal) A) Supply, B) Supply hot spot analysis C) Demand and D) Demand hot spot analysis. Supply was analyzed by calculating the percentage of area occupied by riparian forests and woodland (3.1.1. Broad-leaved forest, 3.1.2. Coniferous forest, 3.1.3. Mixed forest, 3.2.1. and 3.2.4. Transitional woodland shrub) water lines buffer strip of 25 meters as a proxy. Demand was assessed by calculating the percentage of area occupied by croplands (2.1.1. Non-irrigated arable land, 2.2.2. Fruit trees and berry plantations, 2.4.2. Complex cultivation patterns and 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation) as a proxy. Data was calculated at the eldership level. Sources: Corine land cover 2018 (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018) and water courses Lithuanian Cadastre (https://www.registrucentras.lt/). More information about the the assessed ES in: http://linesam.mruni.eu/

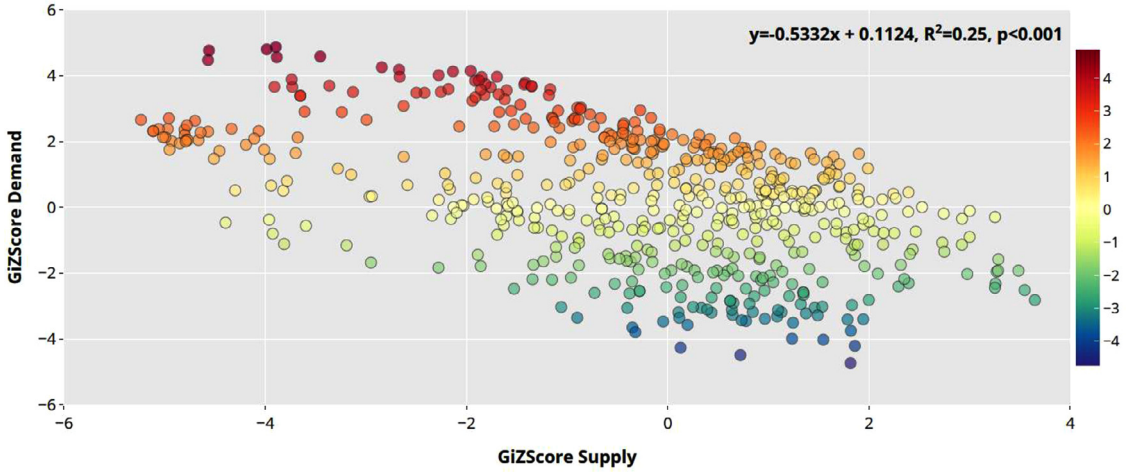

Fig. 2. Relation between GiZ Score of Supply and GiZ Score of Demand obtained from mediation of wastes or toxins substances hot spot analysis.

Fig. 3. Water course in an agricultuire area intensively managed (Lithuania).

stronger interest than development of housing, irrespectively private or public (ECHR, 2019).

Public lands are expected to be important habitats to support ES provisioning. This can also be obtained in private lands. However, the operationalization and implementation of ES in private territory is difficulted because of private property rights. In modern democracies, private property is extremely protected, and it is a challenge of sustainability targets, since some rights can be infringed (Bartkowski et al., 2018). In this context, it is essential to increase the private stewardship regarding the maintenance of ES. In urban areas, Cerra (2017) defined four strategies to increase stewardship in private property, 1) indirect incentives, 2) community-based initiatives, 3) market-based certifications and PES. Normally PES helps market some ES, and some compensation can exchange them. This strategy is the most commonly used and the focus of this work. PES payments can be executed in cash, kind, or a mixture of these two. The payments in kind can be in microcredit, loan waivers, and provision of services. PES is divided into public and government payments and private payments (Gundimeda et al., 2012; Cerra, 2017). Overall, PES can prevent ES overexploitation and the need to restore a degraded ES (Bellver-Domingo et al., 2016). Recently Guo et al. (2020) reviewed the methods applied in PES. These schemes have been implemented in several regions of the world such as America (e.g., Brownson et al., 2019), Europe (Ovando et al., 2019), Asia (e.g., Huang et al., 2018), Africa (e.g., Benjamin and Sauer, 2018) and Australia (Robinson et al., 2016) with the aim of conservation and restoration of degraded lands. PES was carried out to maintain/increase several ES in private lands such as flood regulation (Collentine et al., 2018), carbon sequestration (Farley et al., 2013), water provisioning (Sone et al., 2019), air purification and climate regulation (O'Sullivan et al., 2017). The tradeoffs existent between ES, limit the effectiveness of PES schemes. For instance, in several cases, management decisions in afforestation large areas to increase ES regulating capacity (e.g., soil retention, carbon sequestration) may result in the reduction of other provisioning services (e.g., crop production and water) yield as occurred in Loess Plateau (China) after Grain for Green project (Yu et al., 2020). A similar situation was identified in Spain after rural exodus, where the increase of trees and shrubs is responsible for reducing water yield and groundwater recharge (Ovando et al., 2019).

Although PES has been widely disseminated, there are several limitations that independently of the scheme applied remain to be solved such as transaction costs, high establishment, limited the ecosystem provision and low inclusivity of participation. Participation in PES schemes decreases with the increase with poverty and education and rights. Other obstacles to PES implementation were limited funding, institutions reactive approach, reduced political support, lack of proactive behavior, impossibility to do cultural practices, reduced access to the land, decrease of the agriculture area, power relations benefit visions of the nature that are not the same of the local communities such as the reduction of sociocultural practices (e.g., hunting), changing of lifestyles and traditions and the reduced term of PES projects that normally lead to uncertainty after the project end. On the other hand, the effectiveness of the PES projects decreases with age (Ghazoul et al., 2009; Davies et al., 2017; Bremer et al., 2018; Huang et al., 2018; Ren et al., 2018; Wang and Wolf, 2019).

Apart of environmental goals, PES schemes also aim to increase regional development and increase the poverty alleviation (Wang and Wolf, 2019). They can reduce economic inequity and be socially progressive (Wang et al., 2017a). PES is mainly focused on conservation, and very often, tradeoffs are observed between environmental conservation and poverty alleviation. This can be problematic since the improvement in some ES does not mean that will improve the living conditions of local population. For example, several PES schemes reduce the arable area in favor of afforestation, reducing the farmers' income. The impacts of PES in poverty alleviation (Oreoluwa et al., 2019) are diverse and some found that they were effective in increase the wellbeing of local populations (e.g., Pagiola et al., 2005; Tang et al., 2013; Wang et al., 2017b), while others do not contribute (Diswandi, 2017) or had a negative effect (Cao et al., 2010). There are several aspects key to the success of PES in poverty alleviation and get "win-win situations": 1) the sustainability and long term of PES projects, 2) identify the groups that benefit and provide it, 3) know in advance the areas were PES can be applied, 4) recognize the needs of landowners and 5) monitoring the ES (Huang et al., 2018).

4. The way forward: How to be effective in maintain or improve ecosystem services in private property

The fact that there are restrictions in operationalizing and implementing ES in land use planning does not mean that this obstacle cannot be tackled. The existence of legal mechanisms that encourage (e.g., PES)/request (e.g., restrict a certain land use) private owner to implement PES in their lands, offer some hope regarding the operationalization and implementation of ES in practice in legal private property. However, for this to become a reality, control and proper communication are needed. The decade that we have ahead is full of challenges and they are not possible to be achieved without considering the implementation of ES in private property. Private owners must recognize this and minimize the tradeoffs between environmental conservation and well-being of rural communities. The UN established the next decade (2021-2030) as the decade for ecosystem restoration (UN Decade, 2019). According to UN "*There has never been a more urgent need to restore damaged ecosystems than now*," and there is a need to "*prevent, halt and reverse the degradation of ecosystems worldwide*." This strategy is a Global PES to reverse the ecosystems degradation and the loss of biodiversity that is occurring at an unprecedented rate (UNEP, 2019). For this be a reality, private owners have to be committed to other stakeholders such as public authorities and NGOs and understand the need to have sustainable practices and land uses to prevent the loss of ES onsite and offsite their properties. This can be crucial in several cases to prevent floods downstream, biodiversity loss, surface and groundwater pollution, water provisioning, and land degradation. "*There is no more time to wait*", the humanity needs to adopt sustainable practices to reduce the ecological footprint (Pereira, 2020), and for this, private owners need to participate actively. Their involvement is also fundamental to achieve UN SDGs.

5. Conclusions

ES and legal protection of private property can be a problem or solution depending on the approach and how we deal with private interests. Knowing the local communities and their needs is very important. Considering this aspect may transform a problem in a solution. Incorporating ES in land use planning is of key importance to identify the losses that may occur if certain land use is changed. For this, mapping ES has an important role since it resume the information and can communicate easily complex data (e.g., spatial models and relations between different indicators/variables). Maps can help to identify the areas with high ES value or that required a restoration to increase ES delivery. Nevertheless, these areas can belong to private owners. In this case, it is crucial to implement effective schemes such as PES, increase the acceptability and awareness of private owners to the importance of ES delivery, and how the land use carried out can have impacts onsite and offsite. Sustainable land use is fundamental to the long-term delivery of ES in quantity and quality. We face critical challenges regarding the tradeoffs associated with PES programs that can reduce local communities' incomes and loss of cultural practices, which are part of the identity. Above all, PES must contribute to poverty alleviation, which is the basis of building a mature society, ready to contribute to global achievements such as UN SDGs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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